

Initial State Helicity Correlation in Wide Angle Compton Scattering

Shigeyuki Tajima (UVa)

Jefferson Lab **WACS** Collaboration

Spokespersons:
Donal Day (UVa) and Bogdan Wojtsekhowski (JLab)

Hall C January Meeting on Jan.26, 2007

WACS Collaboration

P. Bosted, J. P. Chen, E. Chudakov, K. DeJager, R. Ent, R. Feuerbach, J. Gomez, D. Gaskell,
O. Hansen, D.W. Higinbotham, M. Jones, J. LeRose, D. Mack, R. Michaels, S. Nanda, B. Reitz,
A. Saha, S. Wood, **B. Wojtsekhowski (spokesperson) TJNAF**

G. Cates, D. Crabb, **D. Day (spokesperson)**, R. Lindgren, N. Liyanage, V. Nelyubin,
O. Rondon, K. Slifer, L.C. Smith, S. Tajima, **Justin Wright** (Graduated with M.S.),
Melissa Commisso UVa

R. Asaturyan, K. Egiyan, V. Mamyran, H. Mkrtchyan, T. Navasardyan, A. Shahinyan, V. Tadevosyan,
H. Voskanyan **Yerevan Physics Institute**

D. Nikolenko, I. Rachev, Yu. Shestakov **Budker Institute**

F. Butaru, A. Lukhanin, Z.-E. Meziani, B. Sawatsky, P. Solvignon, H. Yao **Temple**
P. Markowitz **FIU**

M. Khandaker, V. Punjabi, F. Wesselmann **Norfolk State University**

B. Crowe, B. Vlahovic **NC Central University**

C. Glashauser, R. Gilman, X. Jiang, G. Kumbartzki, R. Ransome **Rutgers**

E. Piasetzky, G. Ron **Tel Aviv University**

C. Perdrisat, L. Pentchev **W&M**

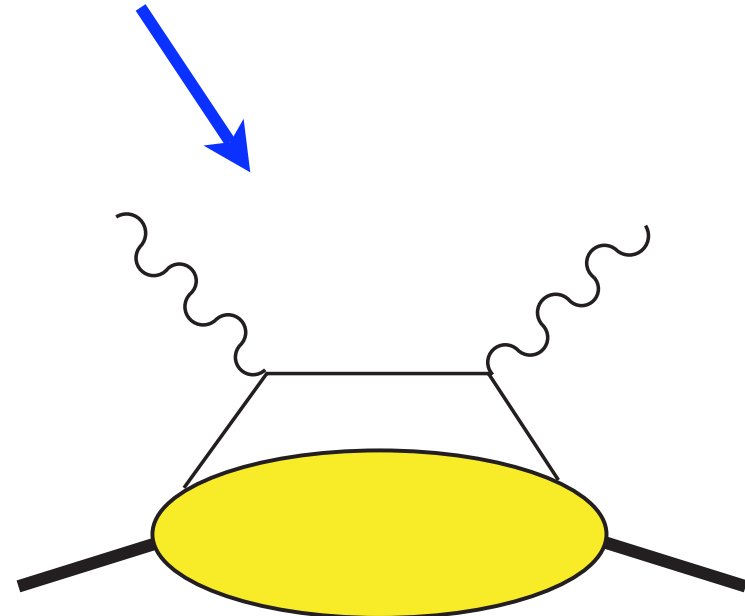
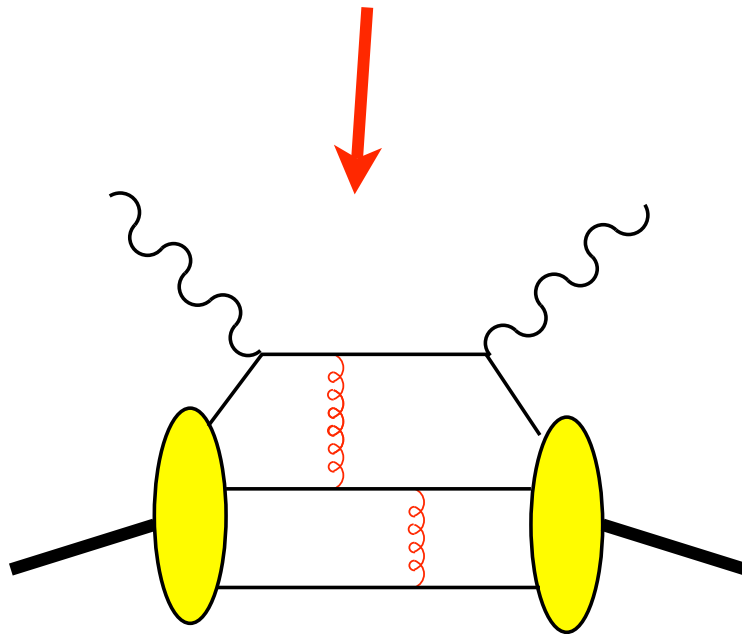
C. Hyde-Wright, A. Radyushkin **ODU**

D. Margaziotis **California State University Los Angeles**

Garth Huber **University of Regina**

Motivations

- Probing hard exclusive reaction by Compton Scattering
- Compton Scattering off nucleons provides information on the substructure of nucleon in terms of quark and gluon d.o.f. → extremely complicated
- **Hard gluon exchange** or **Handbag model** ?



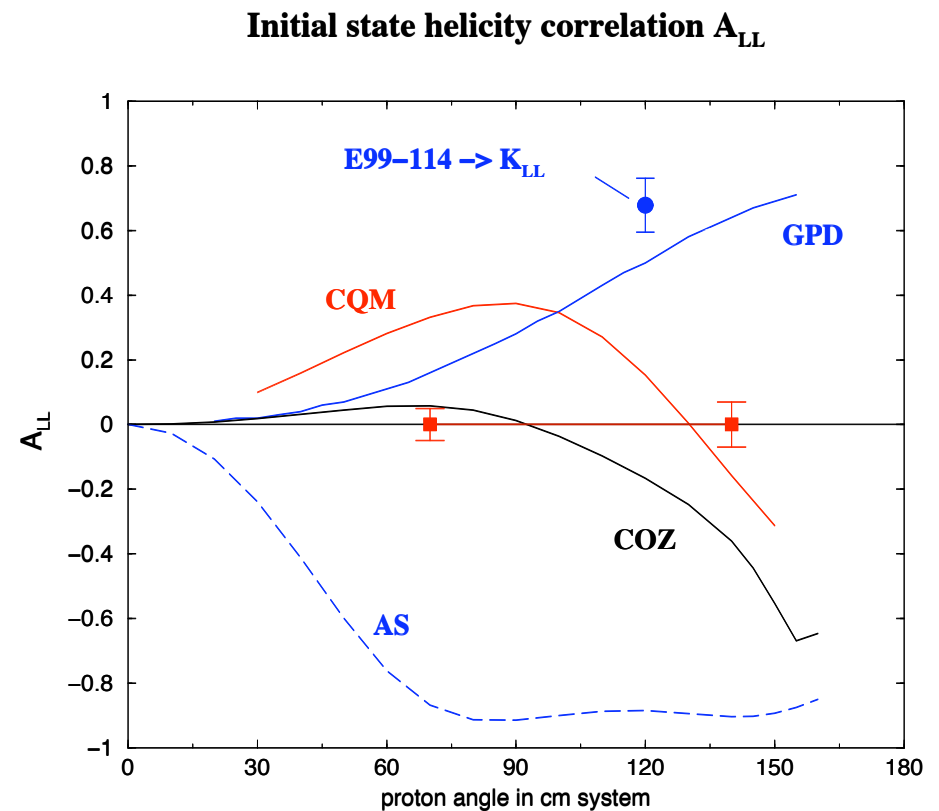
Physics Goals

- Measure the polarization observable A_{LL} (never been measured) at $\theta_\gamma = 140^\circ$ (CMS), corresponding to $-t = 6.4 \text{ (GeV/c)}^2$

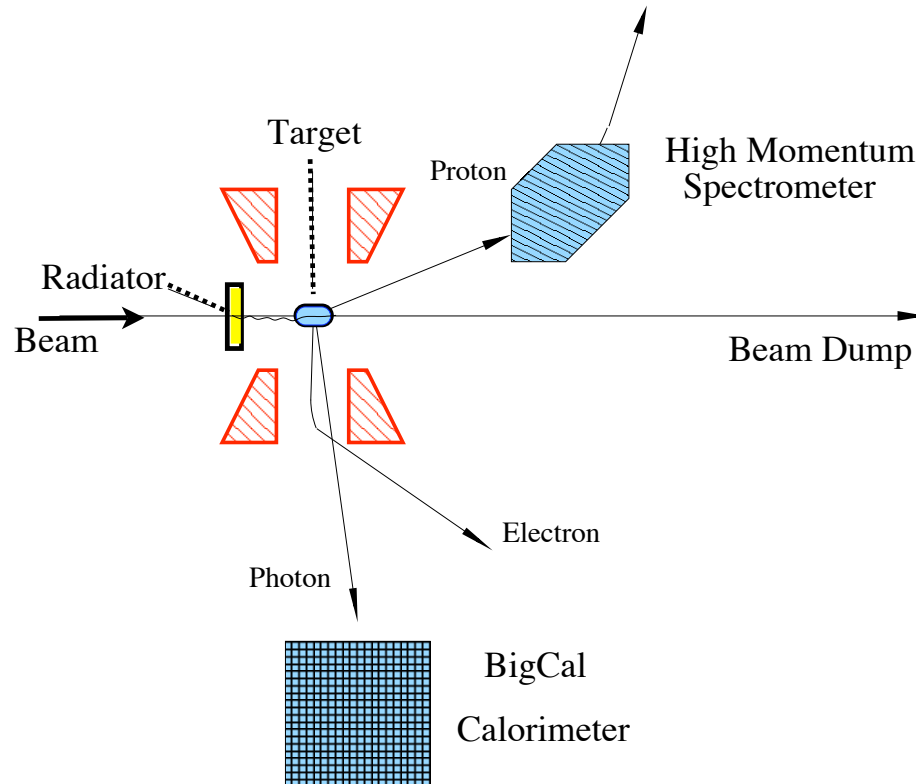
$$A_{LL} \frac{d\sigma}{dt} = \frac{1}{2} \left[\frac{d\sigma(++)}{dt} - \frac{d\sigma(+-)}{dt} \right]$$

- Statistical accuracy of A_{LL} is better than ± 0.1
- Provide an experimental test of the RCS reaction mechanism: does the photon interact with a constituent or a current quark?

Predictions for A_{LL} in GPD (Kroll) and CQM (Miller) approaches



WACS Experimental

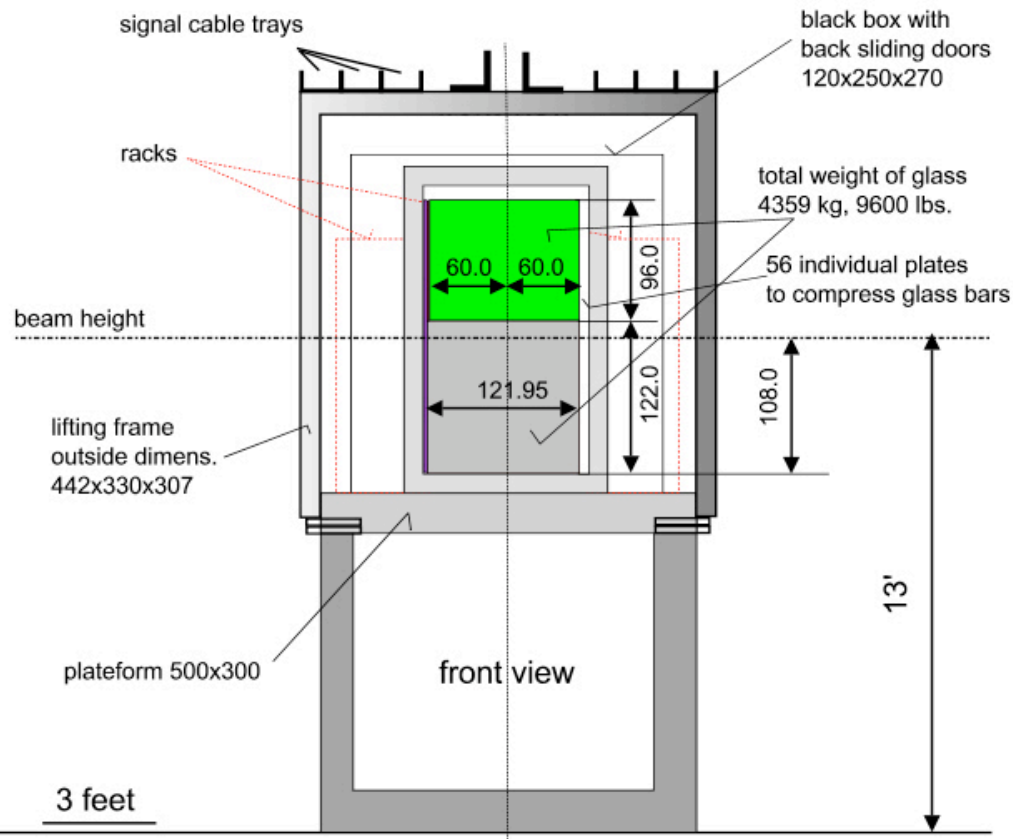


- Will run with SANE
- Polarized electron beam (**4.8GeV**)
- Electron Beam current $\sim 90\text{nA}$
- **Radiator** (Cu 10% , 1.43mm thick) to produce gammas
- Mixed $e-\gamma$ beam at the target
- UVa Polarized (NH_3) Target: 5T magnetic field applied.
- **Longitudinal** Target Polarization
- **Longitudinally polarized photons** scattered from a longitudinally polarized proton target.

Run type	Beam Energy (GeV)	BigCal energy (GeV)	BigCal Angle (deg)	P_{HMS} (GeV/c)	HMS angle (deg)	Target Field	BigCal Distance (m)
ep Elastic	4.8	3.0	25	2.0	39	off	7.0
Production	4.8	0.9	82	4.3	12	// (5°)	2.5

The Photon Calorimeter: BigCal

01-109 Calorimeter



- Originally built for Gep III
- About 1.2m(W) x 2.2m(H)
- Solid Angle= 0.33sr (BigCal at 2.5m from the target center)
- A total of 1744 lead-glass bars of type TF-I (1024 Protvino + 720 RCS bars)
- Protvino: 32 rows, 32 columns
each bar: 3.8x3.8x45cm
- RCS: 24 rows, 30 columns
each bar: 4.0x4.0x40.0cm
- Energy resolution: 5 %/ \sqrt{E}

GEANT4 Simulation Program

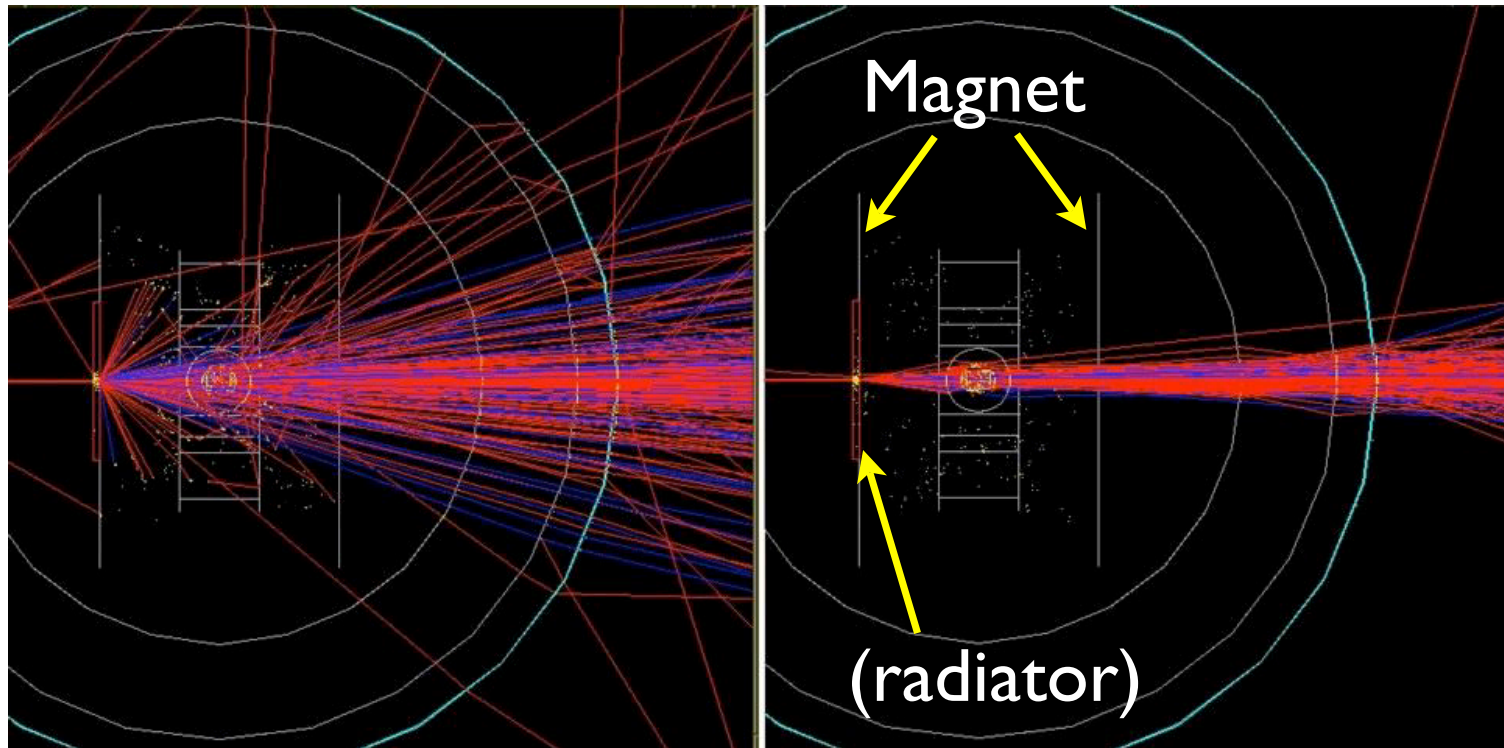
- Work done by **Justin Wright** (UVA, graduated with M.S.) and S.Tajima
- GEANT4 software toolkit (ver 4.6.2) is used
- Purpose of simulation:
 - Background studies (event rates of γ , low-energy electrons)
 - Simulate the response of BigCal
 - Study the effect of 5T target field on charged particles
 - effect of shielding
 - Physics simulations
 - Data Analysis using simulation data
- Status of the program:
 - Geometries of OVC, Nitrogen Shield, Polarized target (NH_3), beamline are already done.
 - BigCal Lead glass bars have been added.
 - Several physics event types are available: Compton $e-\gamma$, elastic ep, Q.E. ep, pion photo-production, Electron beam

Simulation Results

- Scattered electrons are deflected due to the magnetic field
- But *Low energy* charged particles are trapped along the beamline when the magnet field is on.

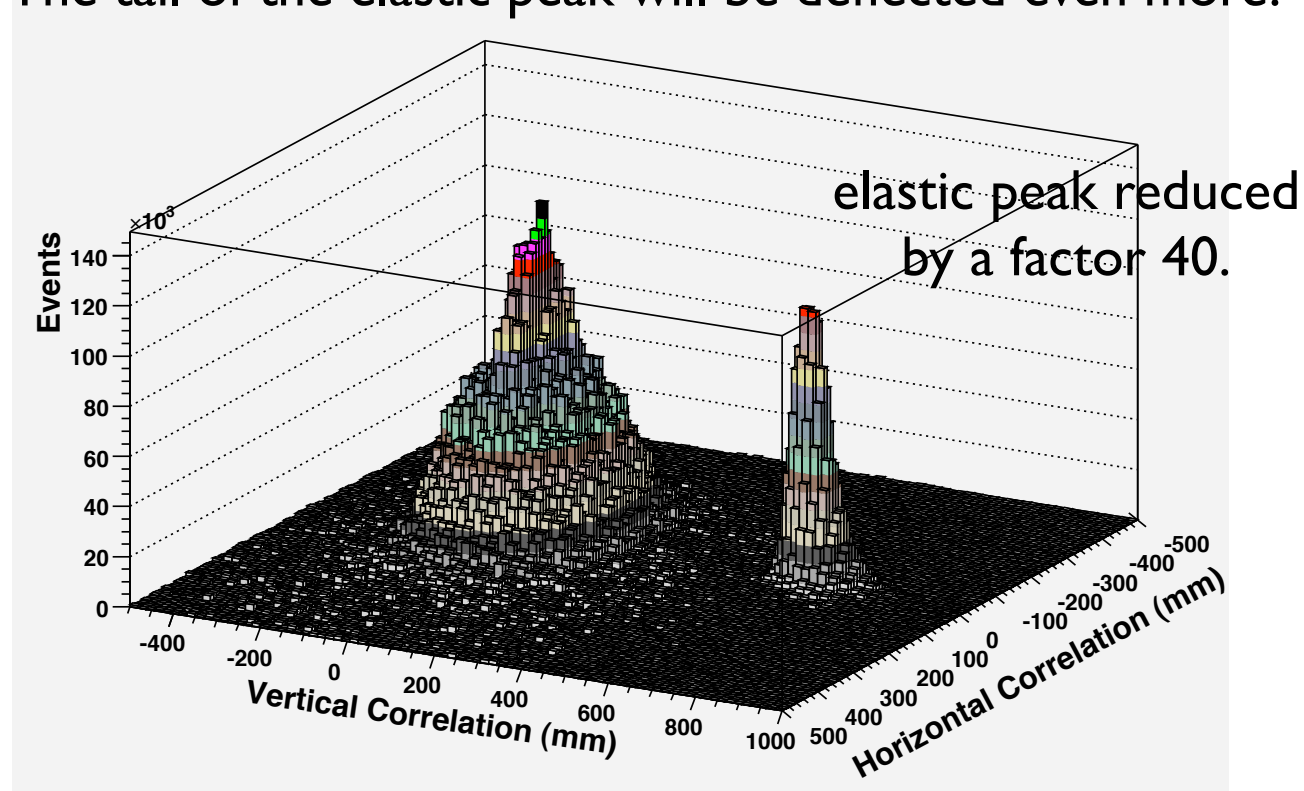
• (Left) Magnetic field OFF

(Right) Magnetic field ON



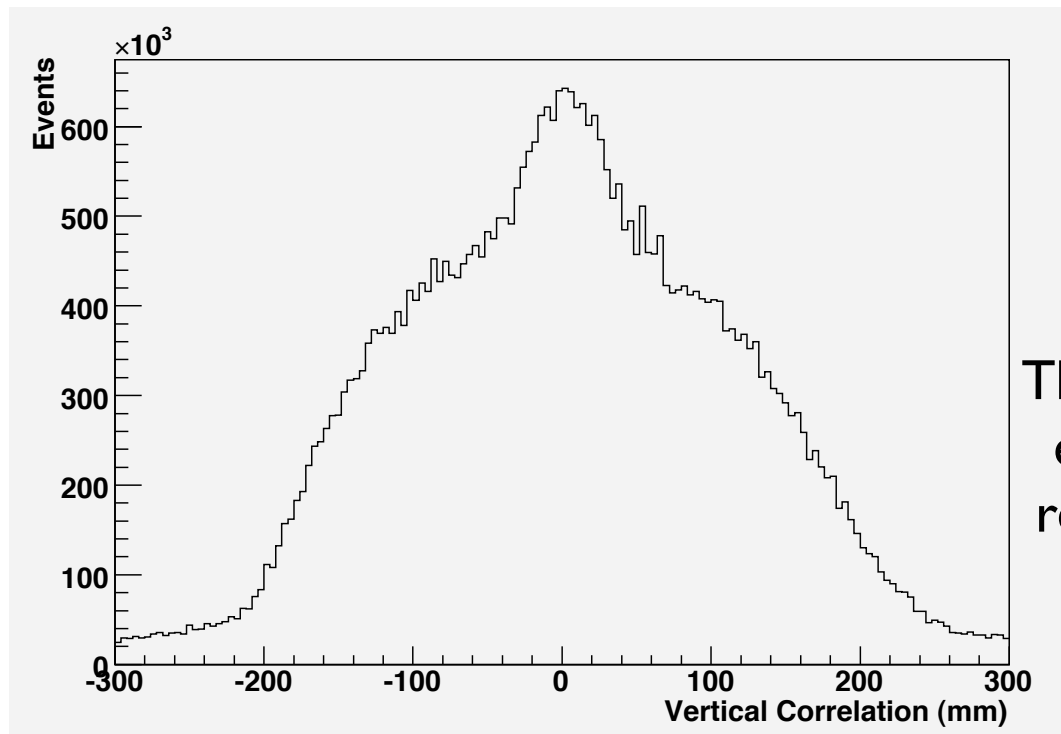
Physics Simulation

- Shown below is the event distribution in the calorimeter versus the **vertical and horizontal correlations**.
- Clear separation of the compton events (left) and elastic electrons (right)
- The tail of the elastic peak will be deflected even more.



Physics Simulation (cont)

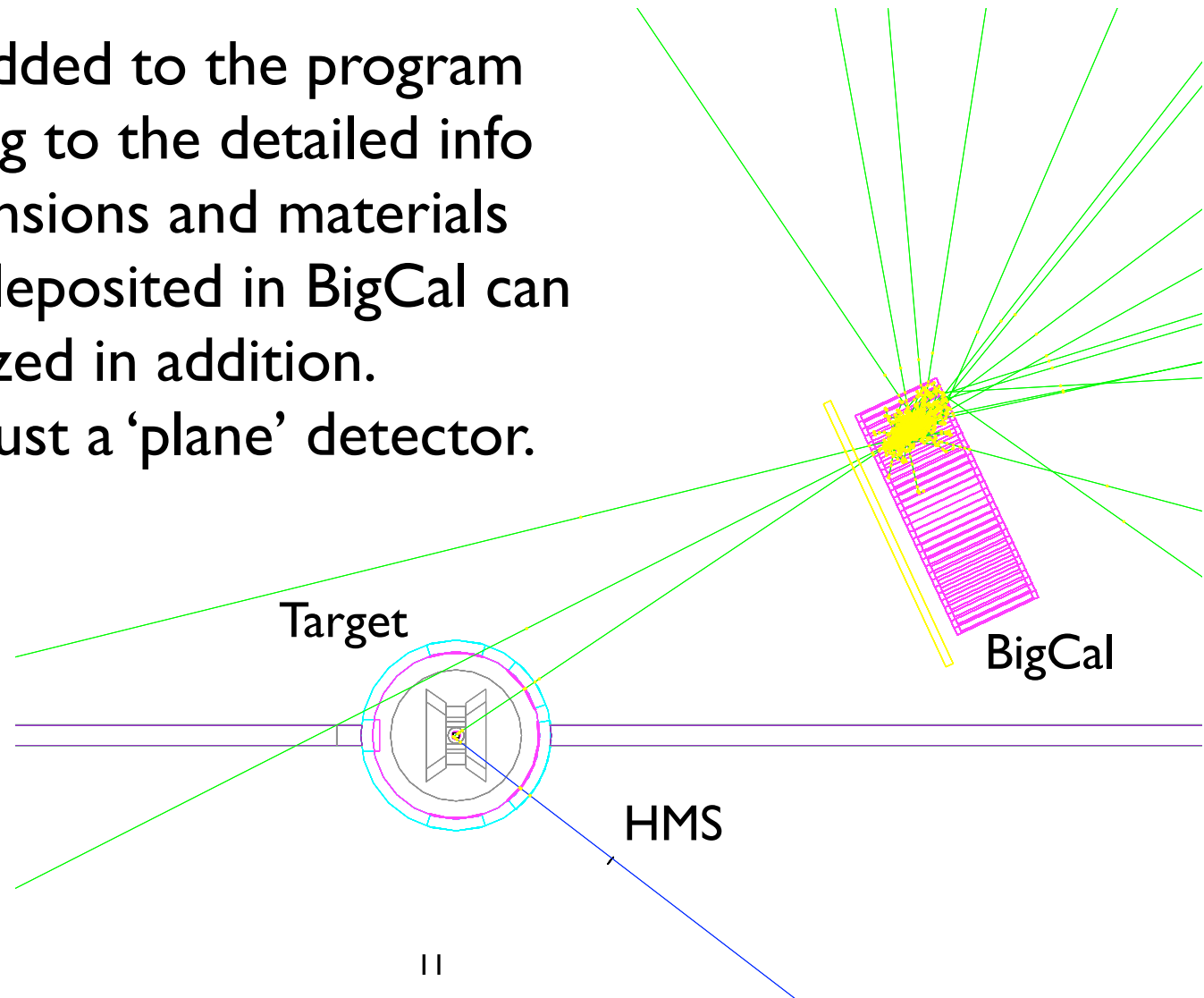
- Shown below is the (Compton and Pion) event distribution versus the vertical correlation parameter
- The compton events from the sharp peak on top of the broad pion background



The elastic electron events have been removed from this plot.

Simulation Program

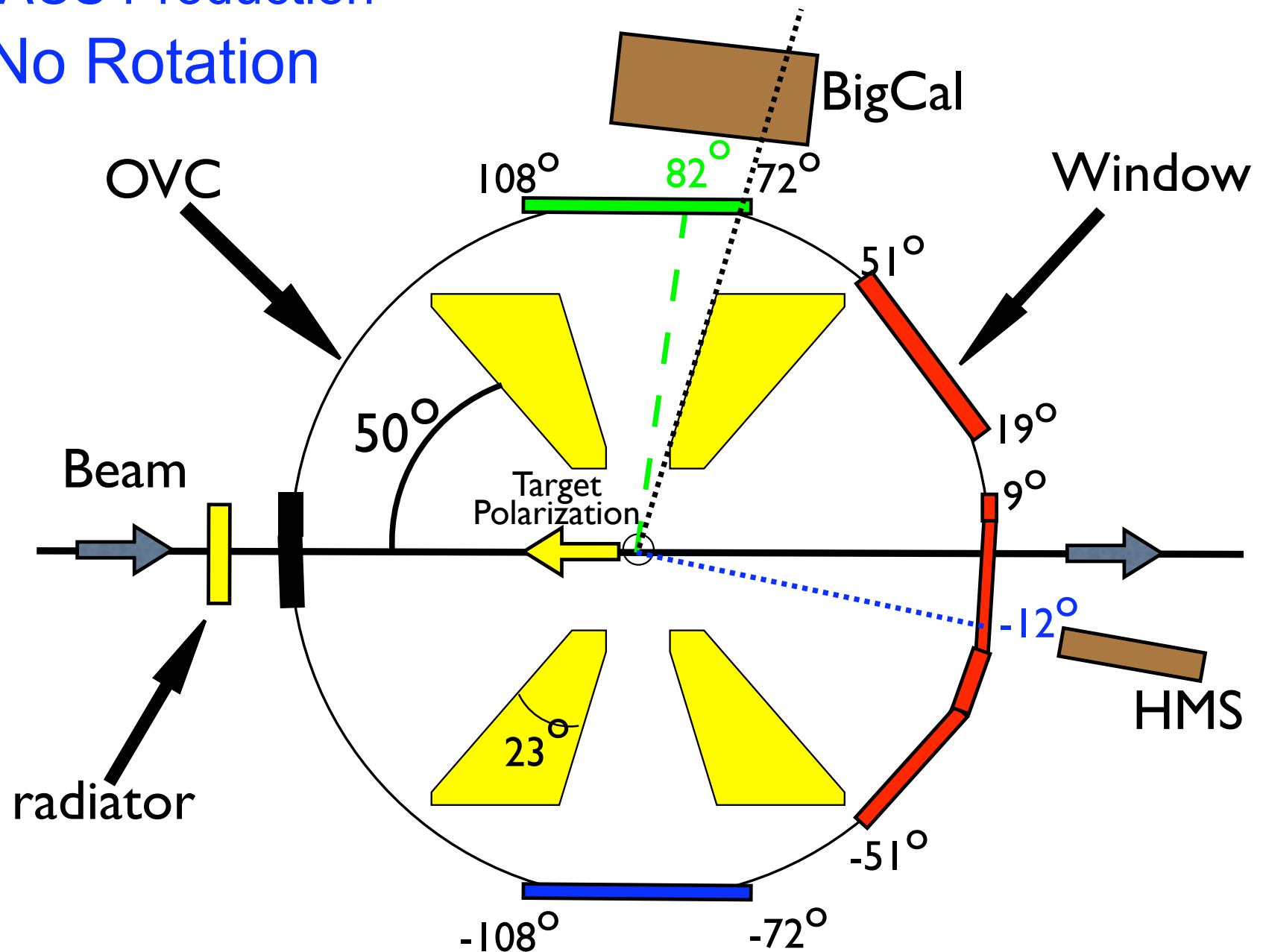
- BigCal added to the program according to the detailed info on dimensions and materials
- Energy deposited in BigCal can be analyzed in addition.
- HMS is just a 'plane' detector.



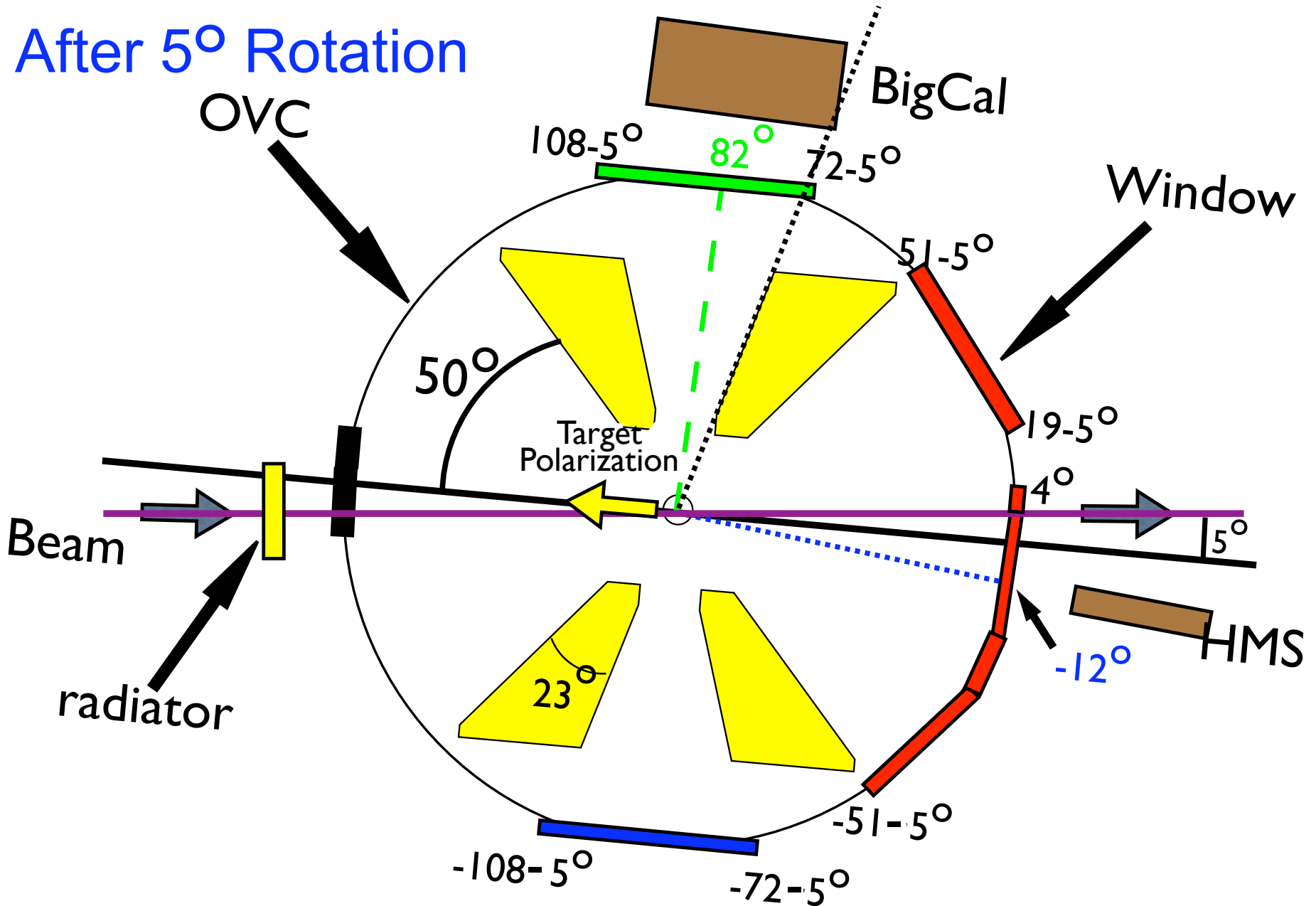
Orientation of the OVC

- For the WACS production running, part of the BigCal acceptance is blocked by the coil when the polarization is parallel (180 deg) to the beam (See the next slide)
- To obtain better acceptance, the OVC could be rotated by 5 deg clockwise.
- **Concern:** Effect of the target field at 5deg on the electrons
- This has to be studied carefully using the GEANT4 simulation before we make a decision

WACS Production No Rotation



WACS Production After 5° Rotation



Other Things to do

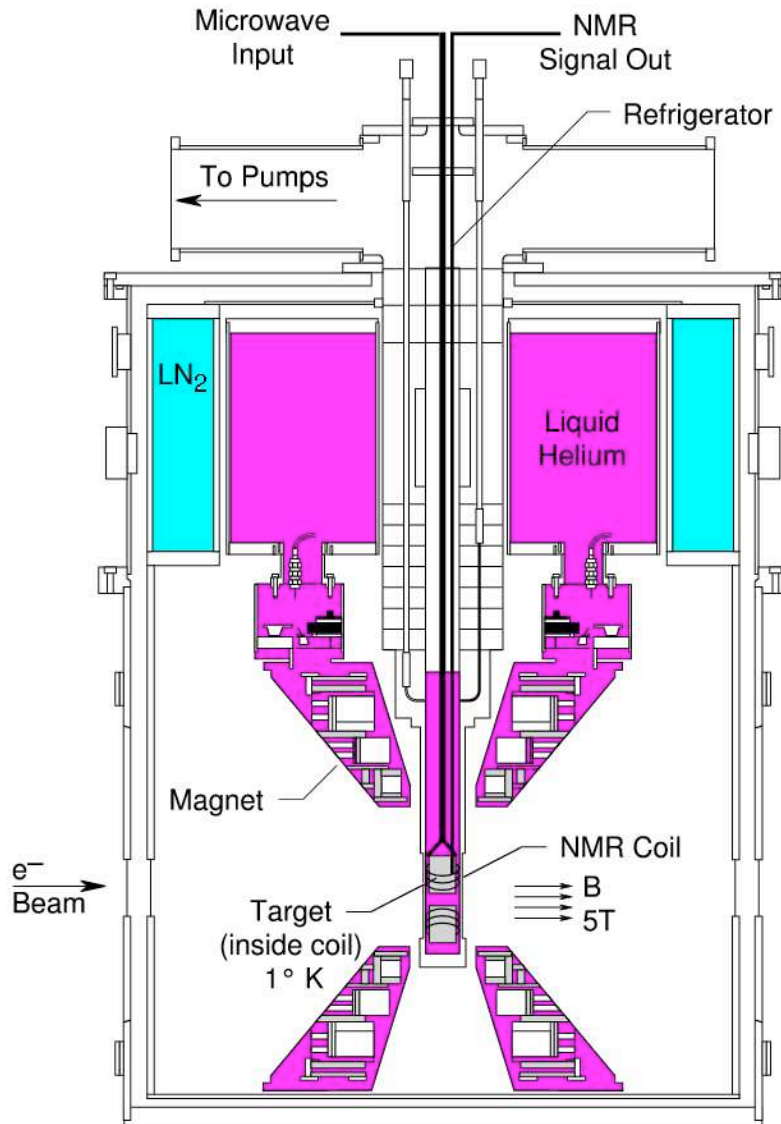
- The GEANT4 simulation program needs to be upgraded:
 - Add HMS
 - Add more physics processes
 - Re-organize the coordinate systems used in the code
 - Re-integrate the root analysis toolkit so that root files can be created much easily.
 - In the future, the simulation program for WACS can be modified for other experiments (such as SANE and Semi-SANE).
- Design of the Radiator (to be placed outside of the OVC)

Conclusions

- WACS will perform a precise measurement of A_{LL} at $\theta_\gamma=140^\circ$ (CMS) [$-t=6.4(\text{GeV}/c)^2$]
- Scheduled to run in 2008
- GEANT4 Simulation program for WACS exists, but still need to be upgraded.
- Need to study the physics background and the effect of 5 deg rotation.



Polarized Target ($^{15}\text{NH}_3$)



- Dynamic Nuclear polarization driven by microwave
- Target ladder contains carbon disc (7mm thick) and two NH_3 cups
- 5T field on target.
- NMR system for polarization measurement
- Polarization can be flipped by 180°. Ran \pm for equal times
- Average target polarization
 $P_T = \sim 70\% (\text{NH}_3)$